Collision Avoidance "Short Course"

Part III: CA Role in Changing Space Flight Environment

Lauri Newman

NASA CARA

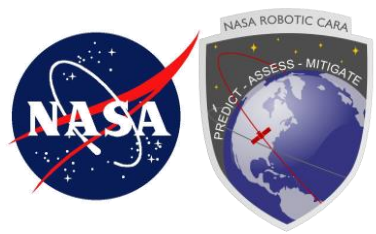
Changing CA Environment

- **Number of different phenomena are changing the environment for conjunction assessment**
  - Deployment of Space Fence radar
  - Changing satellite construction and deployment practices and costs
  - Mega-constellations
  - Non-JSpOC Space Traffic Management initiatives
- **New tools/approaches will be needed to assist CA industry**
  - Collection/publication of CA best practices
  - Orbital registry efforts
  - Expanded data sharing

S-Band Fence

- **New Space Surveillance Network (SSN) sensor expected to increase catalog size significantly**
  - Equatorial phased-array S-Band sensor
  - Can track to better than 5 cm (SSN capability 10 cm)
  - IOC latter part of 2018

- **Expected issues for CA**
  - Vastly increased quantity of new objects (large range of estimates)
  - Quality of maintenance ODs
    - Newly-discovered objects likely to receive light tracking
    - May create additional ops ambiguities and affect event actionability
  - Potential requirement for new CA paradigms to handle workload
    - CA remediation against “grouped” events using an aggregate Pc
    - Station-keeping burn strategy to minimize conjunction risk, without actually remediating individual events unless an extremely high Pc



Changing Satellite Construction/Deployment

- **Ten years ago, satellite construction and operation monolithic**
  - Mostly the domain of large governmental entities
  - Satellites large, multi-purpose, and expensive to build, launch, and operate
  - Development cycles were long and deployments spread out
- **Today, satellite construction/operation completely industrialized**
  - Large base of entirely commercial construction and operation activity
  - Satellites have been miniaturized, greatly reducing construction/launch costs
    - Satellite construction/deployment now even within the reach of hobbyists
- **These developments add considerable complication to CA**
  - Larger number of smaller, potentially maneuverable satellites
  - More difficult to track
  - Some portion fielded by organizations with little to no flight dynamics experience
    - Sometimes do not know the position of their own vehicle
  - Data exchange encumbered by (overzealous) corporate proprietary restrictions

Mega-Constellations

- **Planned mega-constellations will add thousands of active payloads to catalogue**
  - Worst-case analysis indicates order of magnitude increase in serious conjunction events
- **Operational impact large**
  - Development/deployment of new and more highly-automated CA risk assessment tools required

Constellation	# of vehicles	Altitude (km)	Inclination (deg)
Terra Bella	28	576	97.8
Spire	100	651	97.9
Orbcomm	31	750	45.0
Iridium	72	780	86.4
Theia	112	800	98.6
SpaceX VLEO	7518	340	
Boeing	1008	1025	88
SpaceX LEO	4425	1110-1325	53-81
OneWeb	648	1200	88
Boeing	1948	1275	45-55
LeoSat	120	1400	89
Globalstar	40	1410	52

Space Traffic Management (STM)

- **Need for agency with regulatory authority to perform STM has been debated internationally for years**
- **Two congressionally-mandated studies were produced in the US recently:**
  - Section 110 “Report on Processing and Releasing Safety-Related Space Situational Awareness Data” discussed feasibility of civil agency performing STM function
  - Section 109 “Report on Space Traffic Management Assessments, Frameworks and Recommendations” report investigates potential architectures for a future STM system
- **FY18 President’s Budget request for FAA reflects small amount of funding for a pilot STM study**
- **Function important; scope, methods, and ultimate hosting organization presently unclear**

CA Best Practices

- **Multiple challenges and abundance of new actors counsel development and publishing of CA best practices**
  - 20 years of HSF and robotic CA have produced robust CA CONOPS, toolsets, and best practices
  - Some collections already publically available
    - SpaceTrack.org
    - Secure World Foundation Handbook for New Space Actors
  - NASA effort underway to collect and codify its own best practices
- **Should become "living" intellectual property**
  - Updated and published as industry changes
  - Collaboratively assembled
- **Growing academic and operational conferences with CA sessions and focus can support this**

Orbital Registry

- **Propose an "Orbital Registry" service similar to ITU function for GEO**
  - ***Deconflict orbital placement***: provide evaluation of mission orbit selection during design phase to determine impact from close approach perspective and offer trade space of alternative orbits
    - Similar to filing flight plans; during license evaluation is too late to change orbit selection – should be during design
    - Tweaking orbits by a few km can make a big difference in reducing the number of close approaches with neighbors
    - Allows for advance notice of potential co-locations so that they can be avoided or managed smartly
  - ***Maintain database of operator contact information***
  - ***Enable protected data sharing***: Sharing ephemerides is critical for powered flight/low-thrust modelling, yet operators need to be ensured that their sensitive data is protected.
    - Centralized screening service would allow trusted agent to do this screening while keeping data secure
  - ***Serve as repository for best practices/guidelines***

Data Sharing

- **Electric propulsion spacecraft need to share ephemeris data in order to enable CA**
  - "Unperturbed" orbit solutions for these objects will be grossly inaccurate
- **Even for impulsive-burn spacecraft, ephemeris sharing important**
  - Unperturbed solutions have no knowledge of planned future burns
- **Organization and structure needed to receive such data and use for screenings**
  - JSpOC/18th currently not performing this, but future upgrade planned
  - SDA can perform O/O to O/O screenings for members, but not O/O against covariance-enabled space catalogue
  - O/O can perform screenings themselves with access to other O/O ephemerides
- **Different attitude about data sharing required**
  - Orbital safety more compelling than proprietary concerns about satellite ephemeris